Bonneville Spillway Channel TDG 2007 Using Submersible Pumps

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for
U.S. Army Corps of Engineers, Portland District
Contract DACW68-03-D-0003
Task Order DT04
June 2007

TDG Monitoring Using Submersible Pumps

- An alternative method using a submersible pump to deliver sample water to an onshore instrument was evaluated during the summer of 2006.
  - standard ½ hp well pumps readily available at low cost
  - Easily deployed
  - Low power consumption
- The testing was completed at 2 separate locations adjacent to existing fixed monitors to acquire comparable data for the evaluations.
  - the first location tested was adjacent to The Dalles tailwater monitor (TDDO) in the Columbia River
  - the second was located adjacent to the Cascade Island station (CCIW) in the Bonneville Dam spillway channel.
- Submersible pumps placed at depth in the river can maintain positive pressure equivalent to or greater than the hydrostatic pressure of the sampled water as required to maintain air in solution
- Flow-through pumped approach had the advantage of minimizing any temperature changes of the sample due to the short retention time of the sampling system
  - Sources of heat include solar warming and inductive warming from the pump

TDG Monitoring Using Submersible Pumps
Observations:

- The monitor comparison results were consistent for both locations tested
- Minor differences were noted between the in-situ measures and those taken from a standpipe containing pumped sample
- The mean differences for both TDG pressure and water temperature were less than what might occur due to inherent instrument variability and when TDG pressures were corrected for the thermal differences the delta TDG was negligible (1.4 mm Hg and 0.5 mm Hg for The Dalles and Bonneville tailwater monitors respectively)
- The pumped samples averaged 0.5 °C warmer at both test sites.
  - This thermal difference was consistent throughout the normal diel cycles
  - was attributed to inductive warming from the pump operation
- The depth of instrument submersion appeared to produce a bias in the measured TDG pressures

TDG Monitoring Using Submersible Pumps

Comment:

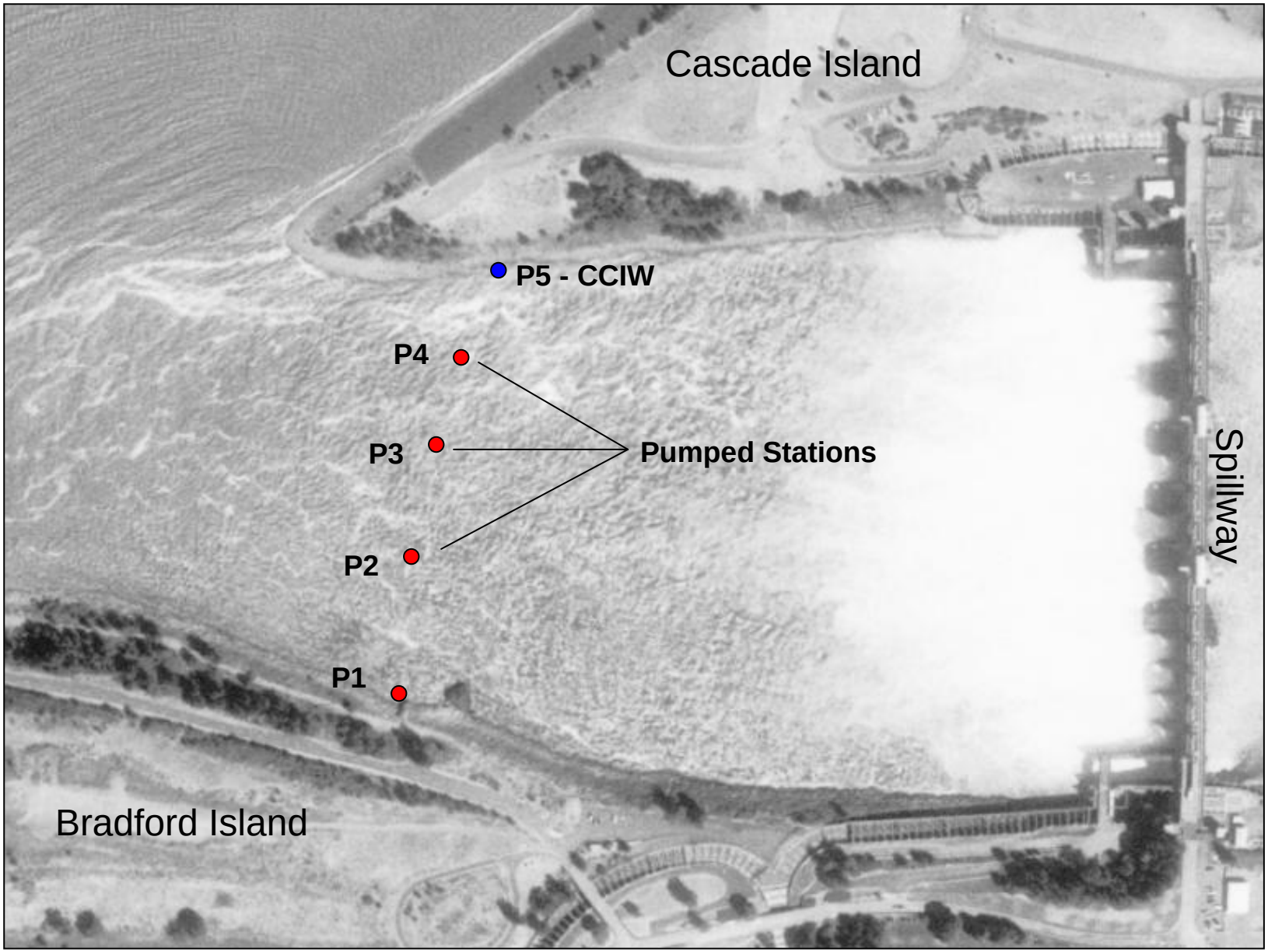
- The manufacturer specifications for the MiniSonde are +/- 0.2 °C for water temperature and +/- 1 mm Hg TDG pressure (Hydrolab Corp) for each instrument. This indicates that the difference between any two instrument readings could be as great as +/- 0.4 °C temperature and +/- 2 mm Hg TDG pressure or +/- 0.26 % saturation before being considered different. This is due to inherent instrument variability combined with potential calibration error.

2007 Study Purpose:

- Further evaluation of the alternative method for TDG monitoring using a submersible pump to deliver sample water to an onshore sensor
- Evaluate lateral gradients in TDG across the Bonneville Dam spillway channel near the fixed monitor CCIW

Approach:

- A lateral transect of TDG measures were collected using a combination of 2 fixed instruments (in-situ) and 3 pumped samples for a total of 5 stations
- The instruments were distributed at near equal distances apart across the spillway channel starting on the left bank downstream on Bradford Island (P1), then 3 in river pumps (P2, P3, P4), and ending with the fixed monitor, CCIW, (P5)


Cascade Island
P5 - CCIW
P4
P3
P2
P1
Pumped Stations
Spillway
Bradford Island

Sampling Methods:

- P1 was placed near shore off Bradford Island and in line with CCIW
- Each in river station employed a submersible well pump placed on bottom (approximately 30 ft deep) and in line with CCIW
- CCIW was used for the P5 station
- Water to be sampled was pumped from the river into a 10 ft (3 m) tall standpipe and then allowed to overflow back into the river. The pump flow rate was 5 gpm
- Each standpipe was equipped with a Hydrolab® Corp DS4a Minisonde water quality monitoring instrument
- Instruments were generally positioned at the bottom of the standpipes at approximately 10 ft deep
- Measurements were collected on 15 minute intervals at each station except P5 which was on 60 minute intervals
- Parameters included water temperature (Temp °C), depth (m), and total dissolved gas (TDG as mm Hg). Total dissolved gas as percent saturation (%) was calculated as the percent of ambient air pressure or barometric pressure (BP from CCIW).
- Thermal corrections were applied to the TDG data for the pumped samples using average temperature differences with P5 (CCIW)

TDG Monitoring Using Submersible Pumps Installation and Components:

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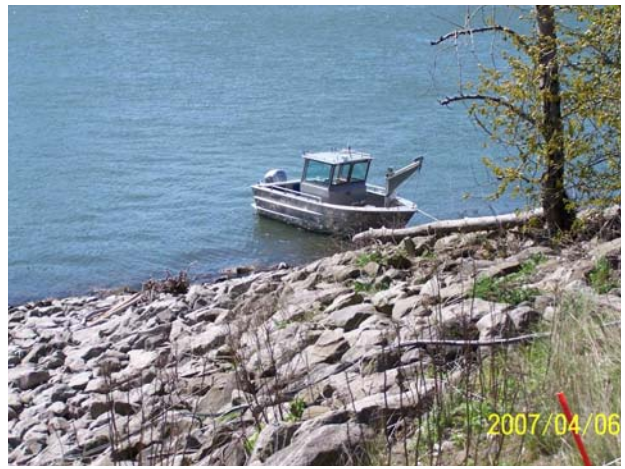


Calibration and Maintenance:

- Calibration and maintenance for each site was performed according to the manufacturers' recommended procedures as described in the instrument manual (Hydrolab ® Corp)
  - prior to deployment
  - following each data download
  - following instrument retrieval and the final data downloads.

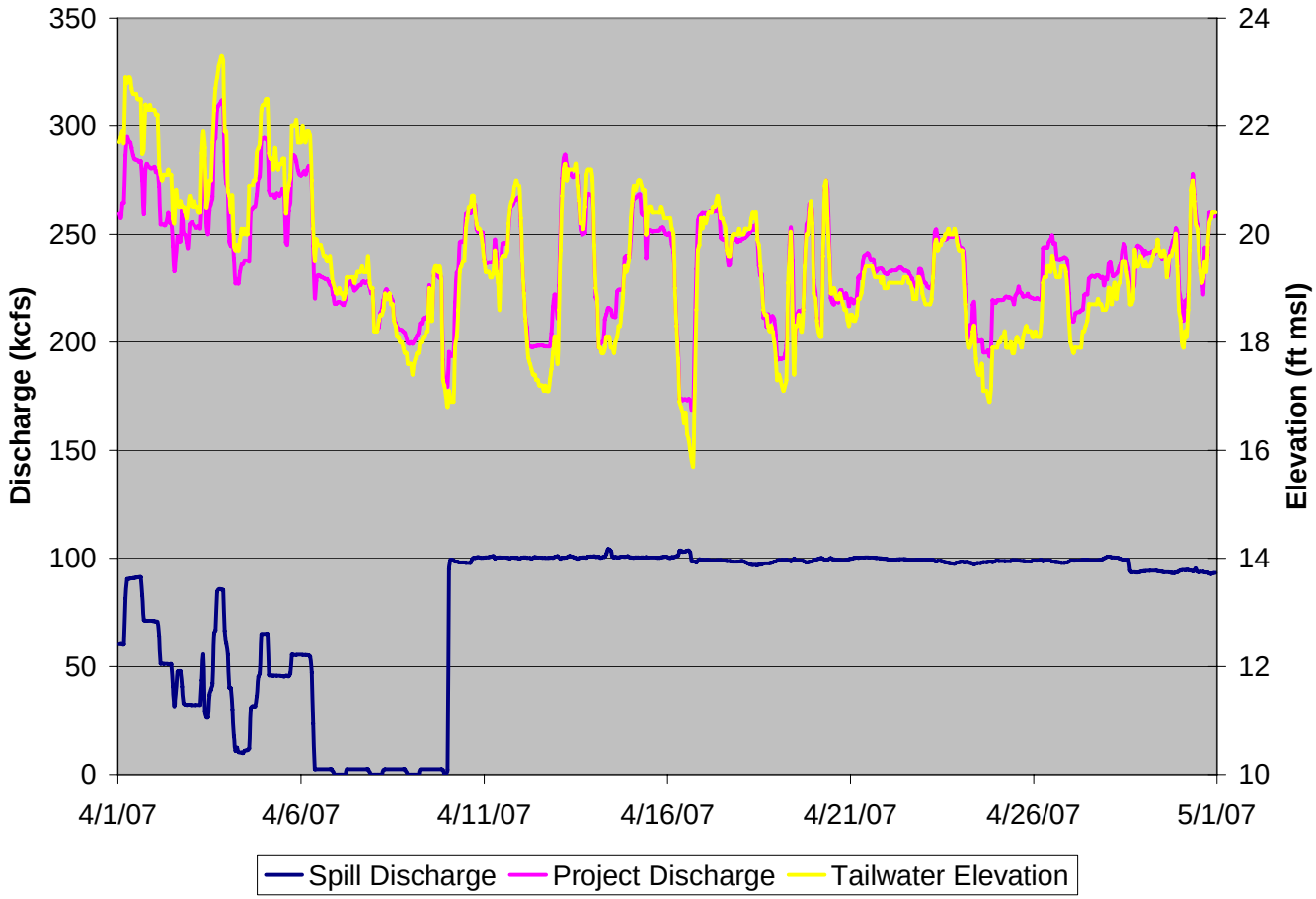
Test Schedule:

- Pumped sampling was first initiated on April 12th
- data collection was started on April 19th following installation of insulation piping to minimize daily solar warming
- Data collection ended on April 30th 2007
- Resulted in a total of 8 days of data with pumped sample measures from 2 of the in river stations
- Bonneville fish spill operation was started on April 10th at 100 kcfs and continued at the discharge throughout the study period

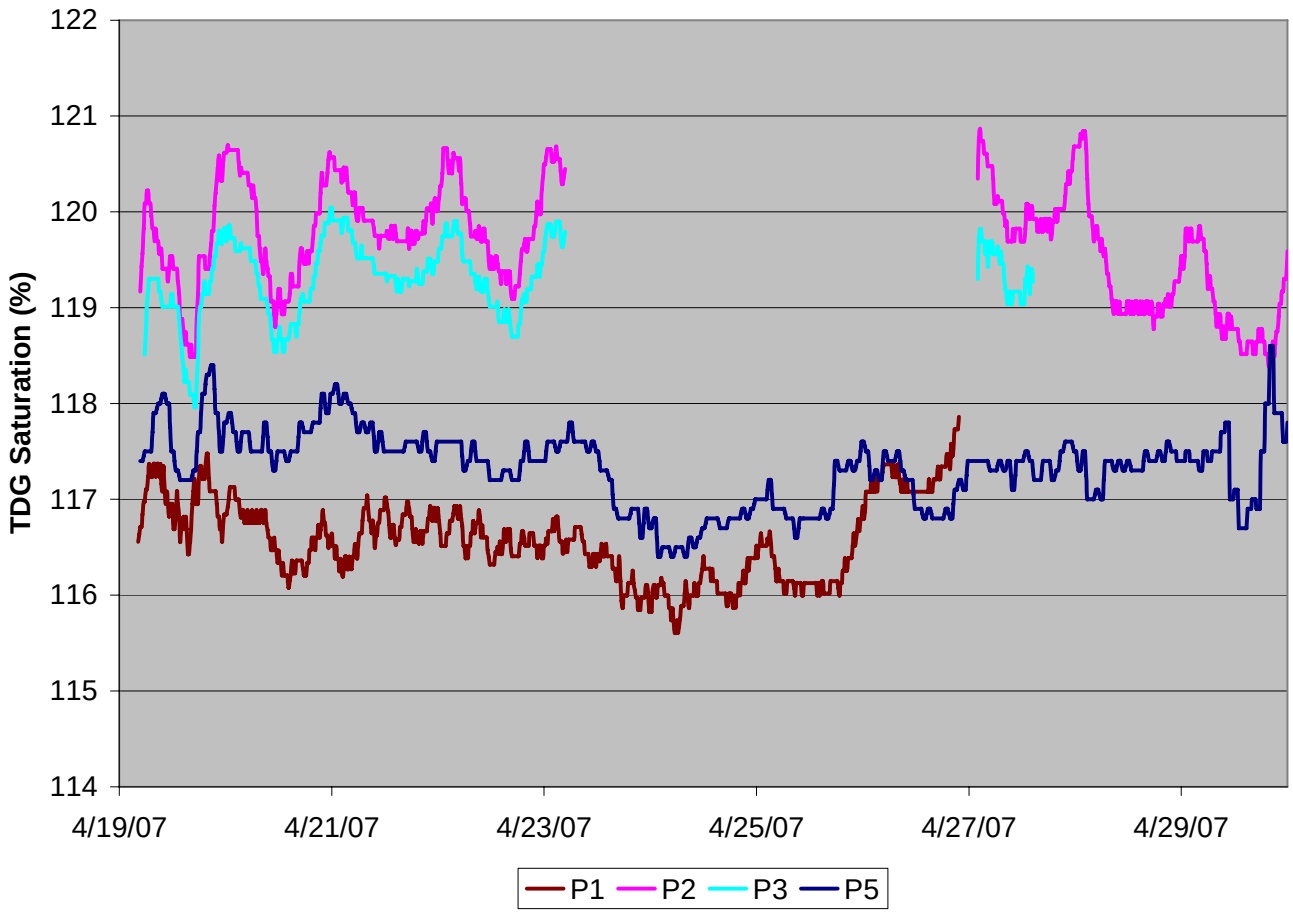
Study Problems:

- P4 pump failed after a few days of operation and before any data collection
- Pumped water demonstrated daily warming cycles which required minimizing pipe lengths and adding thermal insulation to exposed pipe sections
- Power failure from April 23 until April 27 due to fuel outage for generator

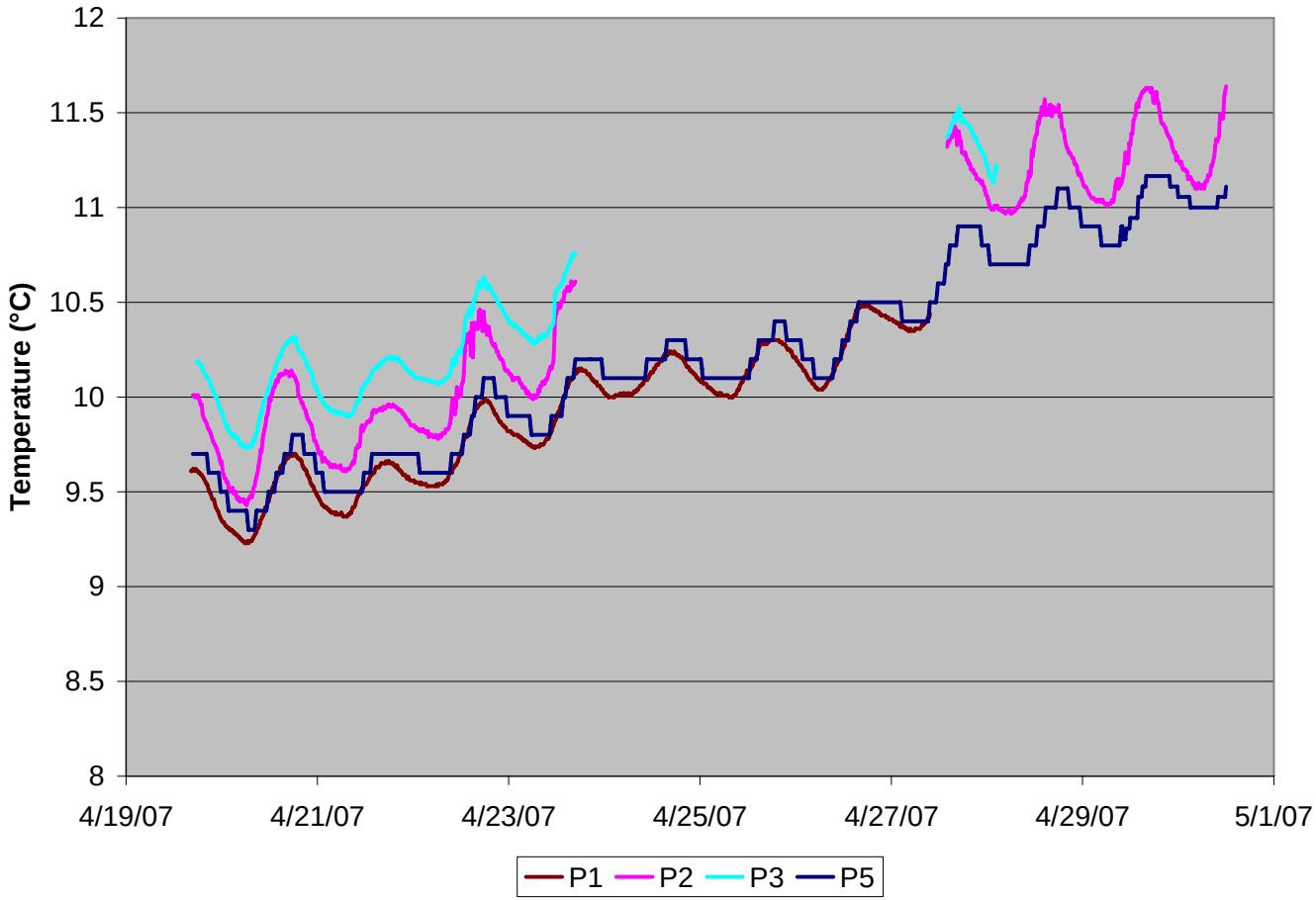
Bonneville Project Operations



Spillway Transect TDG Saturation



Spillway Transect Temperature



Statistical Comparison of Differences in Temperature, TDG Pressure, and TDG % Saturation Between Each Transect Station and Station P5 or CCIW

- Statistics from a one-sample test to compare differences to zero (test value = 0) for all paired readings of P5 and all other transect stations are summarized
- The value for P5 was subtracted from each of the other stations (P1, P2, and P3) in each case
- The differences were then compared to zero with test results
- Differences were small but they were found to be significant at the 95% level for all Variables

Temperature Difference Between Transect Station and Station P5, Statistical Comparison

One-Sample Statistics for Temperature Difference (Station - P5)

	N	Mean	Std. Deviation	Std. Error Mean
DP1Temp	741	-.0691	.04875	.00179
DP2Temp	666	.2804	.13769	.00534
DP3Temp	432	.4905	.07545	.00363

One-Sample Test for Temperature Difference (Station - P5)

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
DP1Temp	-38.567	740	.000	-.0691	-.0726	-.0656
DP2Temp	52.546	665	.000	.2804	.2699	.2908
DP3Temp	135.134	431	.000	.4905	.4834	.4977

TDG Pressure Difference Between Transect Station and Station P5, Statistical Comparison

One-Sample Statistics for TDG Pressure Difference (Station - P5)

	N	Mean	Std. Deviation	Std. Error Mean
DP1TDG	741	-5.5624	3.23082	.11869
DP2TDG	666	16.4367	4.47889	.17355
DP3TDG	436	13.0154	3.06194	.14664

One-Sample Test for TDG Pressure Difference (Station - P5)

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
DP1TDG	-46.866	740	.000	-5.5624	-5.7954	-5.3294
DP2TDG	94.707	665	.000	16.4367	16.0960	16.7775
DP3TDG	88.757	435	.000	13.0154	12.7272	13.3036

TDG % Saturation Difference Between Transect Station and Station P5, Statistical Comparison

One-Sample Statistics for TDG Saturation Difference (Station - P5)

	N	Mean	Std. Deviation	Std. Error Mean
DP1Sat	741	-.7319	.42511	.01562
DP2Sat	666	2.1627	.58933	.02284
DP3Sat	432	1.7284	.36926	.01777

One-Sample Test for TDG Saturation Difference (Station - P5)

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
DP1Sat	-46.866	740	.000	-.7319	-.7625	-.7012
DP2Sat	94.707	665	.000	2.1627	2.1179	2.2076
DP3Sat	97.287	431	.000	1.7284	1.6935	1.7633

Conclusions:
(for Spill operations of 100 kcfs)

- Based on the test results pumping TDG samples using a submersible well pump and standpipe gave comparable dissolved gas measures to the fixed monitor data at CCIW
- The pumped stations located near mid channel were significantly higher than CCIW (near shore) in TDG by 1.7 and 2.2 % Saturation for P2 and P3 respectively.
- The P1 station located on Bradford Island averaged 0.7 % Saturation less than CCIW near shore on the Cascade Island side of the spillway channel